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(54) [Title of the Invention]

STORAGE MANAGEMENT SYSTEM

(57) [ABSTRACT]

[Object] To provide a storage management system capable of restructuring logical disks on physical disks for higher speed of access to logical disks and more efficient use of storage capacity of physical disks.

[Constitution] An access-information history database 4 stores history of information on host computers' access to storage units of a storage-unit group 2. An access-information history recording unit 5 stores, in the access-information history database 4, the history information of the access information corresponding to demands for access made by a user to the storage units through the host computers. An access-information history analyzing unit 33 analyses the history information of the access information in the access-information history database 4 and creates prospective logical disks based on the results of analysis. A disk-formation efficiency evaluating unit 32 evaluates the efficiencies of the prospective logical disks based on the results of analysis by the access-information history analyzing unit 33.

[What Is Claimed Is]

[Claim 1] A storage management system of a computer system which comprises a plurality of host computers and a plurality of storage units connected with a network, said storage management system comprising:

an access-information history database storing history of information on the host computers' access to said storage units;

an access-information history recording means recording, in said access-information history database, the history information of the access information corresponding to demands for access given from a user to said storage units through said host computers;

an access-information history analyzing means analyzing the history information of the access information in said access-information history database and creating prospective logical disks based on the results of analysis; and

a disk-formation efficiency evaluating means evaluating the efficiencies of said prospective logical disks based on the results of analysis by said access-information history analyzing means.

[Claim 2] A storage management system of claim 1, wherein said access-information history analyzing means detects the host computers' competitive access to said storage units in time series based on the history information of the access information stored in said access-information history

database and calculates the rates of increase of used storage capacities or the rates of decrease of remaining storage capacities of the logical disks during a certain time period to find logical disks whose storage capacities have to be increased and determine prospective logical disks.

[Claim 3] A storage management system of claim 1 or 2, wherein said access-information history database stores access time, identifiers of host computers demanding access, identifiers of logical disks to be accessed, kinds of access, and write-data quantity.

[Claim 4] A storage management system of any one of claims 1 to 3, wherein said access-information history analyzing means and said disk-formation efficiency evaluating means are activated when there is a demand for addition of new storage units, deletion of storage units, or restructuring of existing logical disks for higher system efficiency.

[Claim 5] A storage medium of a program of a method for a computer to manage the storage units of a computer system which comprises a plurality of host computers and a plurality of storage units connected with a network, said method comprising the steps of:

recording, in the access-information history database, the history information of the access information corresponding to demands for access given from a user to said storage units through said host computers;

analyzing the history information of the access

information in said access-information history database and creating prospective logical disks based on the results of analysis; and

evaluating the efficiencies of said prospective logical disks based on the results of analysis by said access-information history analyzing means.

[Claim 6] A storage medium for a computer of claim 5, wherein said access-information history analyzing step includes:

detecting the host computers' competitive access to the storage units in time series based on the history information of the access information stored in said access-information history database; and

calculating the rates of increase of used storage capacities or the rates of decrease of remaining storage capacities of the logical disks during a certain time period to find logical disks whose storage capacities have to be increased and determine prospective logical disks.

[Claim 7] A storage medium for a computer of claim 5 or 6, wherein said access-information history database stores access time, identifiers of host computers demanding access, identifiers of logical disks to be accessed, kinds of access, and write-data quantity.

[Claim 8] A storage medium for a computer of any one of claims 5 to 7, wherein said access-information history analyzing step and said disk-formation efficiency evaluating step are initiated when there is a demand for addition of

new storage units, deletion of storage units, or restructuring of existing logical disks for higher system efficiency.

[Detailed Description of the Invention]

[0001]

[Industrial Field of Utilization]

The present invention relates to a storage management system. More specifically, it relates to a storage management system capable of restructuring logical disks on physical disks.

[0002]

[Prior Art]

Fig. 8 shows the relation between physical disks 81 and logical disks 82 of storage units 8.

[0003]

When the conventional storage units 8 consisting of physical disks 81 shown in Fig. 8 are used in a computer system, it is usual that each physical disk 81 is divided into two or more logical ones or two or more physical disks 81 are regarded as a single logical one, instead of using the physical disks 81 as they are. By forming such logical disks on physical ones, various users' needs according to their environment and use situation can be met conveniently. Hitherto, considering only the access speeds and the remaining storage capacities of such storage units, logical disks have been formed for the efficient use of storage capacities.

[0004]

Fig. 7 is a block diagram of overall configuration of

a conventional storage management system.

[0005]

As shown in Fig. 7, the conventional storage management system comprises a plurality of host computers 6 connected with a network, a plurality of storage units 7, a storage management unit 63, a database 64 for storing information on the storage units, and a database 634 for storing information on the construction of logical disks. The storage management unit 63 includes a unit 631 for managing the construction of logical disks.

[0006]

The conventional storage management system works as described below.

[0007]

When two or more physical disks are to be added to logical disks, it has to be determined which physical disks are added to which logical disks. At that time, the storage management unit 63 refers to the database 64 for information on the access speeds of available physical disks and chooses physical disks with the highest access speeds as prospective ones. When new storage units have been added to the storage management system to increase the storage capacities of logical disks, the storage management unit 63 refers to the database 64 for information on the remaining storage capacities of the logical disks and chooses logical disks with the smallest remaining storage capacities as prospective ones. Finally, after considering such all information, the storage management unit

63 creates prospective logical disks.

[0008]

[Problems to be Solved by the Invention]

The above conventional storage management system has a problem such that the storage management unit 63 forms logical disks without considering the history of use of disks. In other words, the storage management unit 63 forms new logical disks based on the access speeds and the remaining storage capacities of storage units at the time of its reference to the database 64.

[0009]

Besides, the above conventional storage management system has a problem such that the storage management unit 63 forms logical disks without considering multiple access which affects the performance of the system. In other words, the storage management unit 63 forms new logical disks, considering the average speed of access, or the speed of simple access, to each storage unit 7.

[0010]

To solve the above problems of the conventional storage management system, the present invention provides a storage management system capable of restructuring logical disks on physical disks for higher speed of access to logical disks and more efficient use of storage capacities of physical disks.

[0011]

[Means for Solving the Problems]

According to the present invention, there is provided

a storage management system of a computer system which comprises a plurality of host computers and a plurality of storage units connected with a network, the storage management system comprising: (i) an access-information history database for storing history of information on the host computers' access to the storage units, (ii) access-information history recording means for recording, in the access-information history database, the history information of the access information corresponding to demands for access given from a user to the storage unit through the host computers, (iii) an access-information history analyzing means for analyzing the history information of the access information in the access-information history database and creating prospective logical disks based on the results of analysis, and (iv) a disk-formation efficiency evaluating means for evaluating the efficiencies of the prospective logical disks based on the results of analysis by the access-information history analyzing means, thereby solving the above problems.

[0012]

The access-information history analyzing means (i) detects the host computers' competitive access to the storage units in time series based on the history information of the access information stored in the access-information history database and (ii) calculates the rates of increase of used storage capacities or the rates of decrease of remaining storage capacities of the logical disks during a certain time

period to find logical disks whose storage capacities have to be increased and determine prospective logical disks.

[0013]

The access-information history database stores access time, identifiers of host computers demanding access, identifiers of logical disks to be accessed, kinds of access, and write-data quantity.

[0014]

When there is a demand for addition of new storage units, deletion of storage units, or restructuring of existing logical disks, the access-information history analyzing means and the disk-formation efficiency evaluating means are activated.

[0015]

According to the present invention, there is also provided a storage medium of a program of a method for a computer to manage the storage units of a computer system which comprises a plurality of host computers and a plurality of storage units connected with a network. The method comprises the steps of (i) recording, in the access-information history database, the history information of the access information corresponding to demands for access given from a user to the storage units through the host computers, (ii) analyzing history information of the access information in the access-information history database and creating prospective logical disks based on the results of analysis, and (iii) evaluating the efficiencies of the prospective logical disks

based on the results of analysis by the access-information history analyzing means, thereby solving the above problems.
[0016]

In the access-information history analyzing step, (i) the host computers' competitive access to the storage units in time series are detected based on the history information of the access information stored in the access-information history database and (ii) the rates of increase of used storage capacities or the rates of decrease of remaining storage capacities of the logical disks during a certain time period are calculated to find logical disks whose storage capacities have to be increased and determine prospective logical disks.
[0017]

Further, recorded in the access-information history database are access time, identifiers of host computers demanding access, identifiers of logical disks to be accessed, kinds of access, and write-data quantity.
[0018]

When there is a demand for addition of new storage units, deletion of storage units, or restructuring of existing logical disks for higher system efficiency, the access-information history analyzing step and the disk-formation efficiency evaluating step are initiated.
[0019]

Namely, according to the present invention, the construction of logical disks to be formed anew is determined by considering the situation of past access (or the history

of access) to the physical disks. More specifically, according to the present invention, there are provided in the storage units and host computers (i) access-information history recording means for recording, in response to a demand for access, access information together with elapsed time information in an access-information history database, (ii) an access-information history analyzing means on a computer managing the storage in a system as a storage management unit for analyzing the access information in the access-information history database in time series to find pieces of access information which are distributed to different storage units but related to one another and create prospective logical disks, and (iii) a disk-formation efficiency evaluating means for evaluating the efficiencies of the prospective logical disks. If the prospective logical disks are found positive, the restructuring of logical disks is made by adopting the prospective logical disks found positive. Thus, the access speed and the efficiency in using storage capacity of a computer system are improved.

[0020]

[Preferred Embodiments]

Referring to drawings, an embodiment of the storage management system according to the present invention is now described.

[0021]

Fig. 1 is a block diagram showing overall configuration of the storage management system according to an embodiment

of the present invention.

[0022]

The storage management system according to an embodiment of the present invention comprises a host-computer group 1, a storage-unit group 2, a storage management unit 3, an access-information history database 4, and a logical disk formation database 34, each of them connected with a network.

[0023]

Each host computer of the host-computer group 1 and each storage unit of the storage-unit group 2 are provided with a program-controlled access information history recording unit 5.

[0024]

The storage management unit 3 comprises a logical disk management unit 31, an access-information history analyzing unit 33, and a disk-formation efficiency evaluating unit 32. The logical disk management unit 31 makes physical disks 21 held in a storage of a system (namely, the storage-unit group 2) available to a using body (namely, the host-computer group 1) as logical disks 22.

[0025]

The functions of components of the storage management system are now described.

[0026]

When the host computers of the host-computer group 1 gain access to the above storage units of the storage-unit

group 2, during a certain time period, the access-information history recording units 5 of the host computers and the storage units record history of the information on their access in the access-information history database 4. The access-information history analyzing unit 33 refers to the access-information history database 4 where the access information history is stored and the logical disk formation database 34 which is controlled by the logical disk management unit 31, detects logical disks, according to the access information, which reduces the overall access speed and the overall efficiency in using storage capacity of the system, and creates prospective logical disks. The disk-formation efficiency evaluating unit 32 checks to see if the prospective logical disks raise the overall access speed and the overall efficiency in using storage capacity of the system. If the efficiency evaluating unit 32, after considering the overhead load for restructuring logical disks, finds some of the prospective logical disks to be positive, the restructuring of logical disks is made by adopting the prospective logical disks found positive, or a message is sent to a storage manager to do so.

[0027]

Fig. 2 shows an example of the data stored in the access-information history database 4.

[0028]

The data stored in the access-information history database 4 are access time, identifiers of host computers

demanding access, identifiers of logical disks to be accessed, kinds of access, and write-data quantity.

[0029]

Fig. 3 is a flowchart of the overall processing by the storage management system according to an embodiment of the present invention.

[0030]

Referring to Figs. 1, 2 and using the flowchart shown in Fig. 3, the workings of the access-information history database 4 will be described below.

[0031]

When the storage management system is constructed, logical disks are formed on the physical disks in each of the storage units of the storage-unit group 2 in Step S1. Then, the operation of the system is started.

[0032]

In Steps S2 and S3, when a host computer of the host-computer group 1 gains access to a logical disk of a storage unit of the storage-unit group 2, the access-information history recording units 5 of the host computer and the storage unit record access time and information on the access in the access-information history database 4. The recording in the access-information history database 4 is made while the access is being processed (namely, returning the result in response to the access demand) so that the recording does not affect the access speed. The details of the processing by the access-information history

recording units 5 will be described later with reference to Fig. 4.

[0033]

In Step S4, when there is a demand for addition of new storage units, deletion of storage units, or review of construction of logical disks for higher efficiency, the storage management unit 3 determines whether to review the construction of logical disks or not. If it determines to review the construction of logical disks, it moves to Step S5. If it determines not to review the construction of logical disks, it returns to Step S2.

[0034]

In Step S5, the processing by the access-information history analyzing unit 33 is made. The details of the processing by the access-information history analyzing unit 33 will be described later with reference to Fig. 5.

[0035]

In Steps S6 and S7, the disk-formation efficiency evaluating unit 32 carries out its processing and determines whether prospective logical disks have been created or not. The details of the processing of the disk-formation efficiency evaluating unit 32 will be described later with reference to Fig. 6.

[0036]

Fig. 4 is a flowchart of the processing by the access-information history recording units 5 of the storage management system according to an embodiment of the present

invention.

[0037]

In conjunction with the host computers and the storage units, the access-information history recording units 5 record identifiers of the host computers demanding access, identifiers of logical disks to be accessed, kinds of access, write-data quantity, and access time in the access-information history database 4. The recording is made while access is being processed (namely, returning the results in response to access demands).

[0038]

Step A1 of Fig. 4 is the same as Step S2 of Fig. 3, where the storage management unit 3 receives a host computer's demand for access made by a user to a logical disk of a storage unit.

[0039]

In Step A2, the access demand is processed (namely, in response to the access demand, the logical disk returns the result to the host computer). The processing in Step A2 is made while the processing in Steps A3 to A5 below is being made.

[0040]

In Step A3, the access-information history recording units 5 of the host computer and the storage unit to be accessed identify or determine the identifiers of the host computer demanding access and the logical disk to be accessed, the kind of access, and write-data quantity.

[0041]

In Step A4, the access-information history recording units 5 send the identifiers of the host computer demanding access and the logical disk to be accessed, kinds of access, write-data quantity, and access time to the computer where the access-information history database 4 exists (namely, the storage management unit 3).

[0042]

In Step A5, the storage management unit 3 stores said history information into the access-information history database 4.

[0043]

Fig. 5 is a flowchart of the processing by the access-information history analyzing unit 33 of the storage management system according to an embodiment of the present invention.

[0044]

The access-information history analyzing unit 33 analyzes the access information in the access-information history database 4 and creates prospective logical disks.

[0045]

In Step B1, the access-information history analyzing unit 33 searches the access-information history database 4 to find logical disks each containing data to which access was made within a certain time period. The time interval for detecting the host computers' competitive access to the storage units is given to the system in advance.

[0046]

In Step B2, the access-information history analyzing unit 33 refers to the physical disks which constitute said logical disks and finds the combinations of logical disks using the same physical disks. In Step B3, the access-information history analyzing unit 33 reviews the construction of said logical disks to minimize the number of said combinations and creates prospective logical disks. A threshold value is set in advance so that too many physical disks are not included in a logical disk or if physical disks are added to a logical disk, the total number of physical disks does not exceed the threshold value.

[0047]

The access-information history analyzing unit 33 extracts access information of each logical disk from the access-information history database in Step B4 and calculates the rate of increase of used storage capacity (or the rate of decrease of remaining storage capacity) of each logical disk in Step B5.

[0048]

Finally, in Step B6 and B7, according to the above rates of increase of used storage capacities of the logical disks during a certain time period, logical disks whose storage capacities have to be increased are found and prospective logical disks are calculated. This evaluation is made by estimating the change in storage capacities of the disks till next reviewing of construction of the disks according to a

time period between the previous reviewing and the reviewing of this time and, when the storage capacities are in short exceeding the prescribed threshold value (ratio of the remaining storage capacity), by adding new physical disks to the logical disks.

[0049]

Fig. 6 is a flowchart of the processing by the disk-formation efficiency evaluating unit 32 of the storage management system according to an embodiment of the present invention.

[0050]

The disk-formation efficiency evaluating unit 32 checks to see if the prospective logical disks raise the overall efficiency in using storage capacity of the system.

[0051]

In Step C1, the disk-formation efficiency evaluating unit 32 calculates, with respect to each of the produced logical disks, an efficiency factor when adopting each disk as a pair of a performance factor and a capacity factor (an increase rate in performance due to removal of competitive access and a decrease rate of remaining capacity due to addition of storage capacity). Further, the disk-formation efficiency evaluating unit 32 calculates an overhead factor (restore time of the physical disk and maintenance time of adding physical disks) for the case when the system is changed into the one using above logical disks. Then, efficiency of the prospective logical disk is calculated from the above

efficiency factor and the overhead factor. The efficiency rate can be, for example, calculated by the following equation.
[0052]

$$\text{Efficiency rate} = \sqrt{(aA^2 + bB^2)} - \sqrt{(cC^2 + dD^2)},$$

where A, B, C and D represent an increase rate in performance, a decrease rate of remaining storage capacity, restore time, and maintenance time, respectively, and coefficients a, b, c and d represent weighting constants. The weighting constants a, b, c and d are determined according to the priority placed in advance on each of A, B, C and D.
[0053]

In Step C2, such a prospective disk as the one providing the above efficiency rate equal to or less than the prescribed threshold value is discarded.
[0054]

Finally, in Step C3, in descending order of efficiency calculated above, prospective logical disks corresponding to respective efficiency rates are incorporated into the system as new logical disks.
[0055]

Further, a program for having the above storage management unit carry out the above processing such as a program executing the processing shown in flowcharts of Figs. 3 to 6 may be stored on a storage medium for a computer such as a CD-ROM and a magnetic tape, and distributed. Also, one of the computers at least including a microcomputer, a personal computer and a general-purpose computer may read the above

program from the above storage medium and execute it.

[0056]

[Effects of the Invention]

According to the present invention described above, storage capacity of disks can be used more efficiently by reducing the additional storage capacity of physical disks of no use to the logical disks.

[0057]

Further, since the number of competitive access to the physical disk is reduced by physically separating storage units to which frequent and concurrent access is made, the access speed can be improved.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a block diagram showing overall configuration of the storage management system according to an embodiment of the present invention.

[Fig. 2]

Fig. 2 shows an example of the data stored in the access-information history database of the storage management system according to an embodiment of the present invention.

[Fig. 3]

Fig. 3 is a flowchart of the overall processing by the storage management system according to an embodiment of the present invention.

[Fig. 4]

Fig. 4 is a flowchart of the processing by the access-information history recording unit 5 of the storage management system according to an embodiment of the present invention.

[Fig. 5]

Fig. 5 is a flowchart of the processing by the access-information history analyzing unit 33 of the storage management system according to an embodiment of the present invention.

[Fig. 6]

Fig. 6 is a flowchart of the processing by the disk-formation efficiency evaluating unit 32 of the storage management system according to an embodiment of the present invention.

[Fig. 7]

Fig. 7 is a block diagram showing overall configuration of a conventional storage management system.

[Fig. 8]

Fig. 8 shows the relation between physical disks and logical disks of the storage management system.

[Description of Reference Numerals]

1. host-computer group
2. storage-unit group
3. storage management unit
4. access-information history database
5. access-information history recording unit
21. logical disk

22. physical disk

31. logical disk management unit

32. disk-formation efficiency evaluating unit

33. access-information history analyzing unit

34. logical disk formation database

FIG. 1

1

Host-computer group

2

Storage-unit group

3

Storage management unit

4

Access-information history database

5

Access-information history recording unit

21

Physical disk

22

Logical disk

31

Logical disk management unit

32

Disk-formation efficiency evaluating unit

33

Access-information history analyzing unit

34

Logical disk formation database

FIG.2

アクセス時刻　Access time

要求元　Host computer demanding access

アクセス先　　Logical disk to be accessed

アクセス種別　Kind of access

書き込み量　　Write-data quantity

FIG. 3

S1

Create logical disks

S2

Access from host computer to a logical disk by user

S3

Processing in access-information history recording unit (access time, host computer which gained access, logical disk accessed, kind of access, and write-data quantity are recorded in access-information history recording unit)

S4

Review logical disks?

S5

Processing in access-information history analyzing unit

S6

Processing in disk-formation efficiency evaluating unit

S7

Efficient logical disks exist?

FIG. 4

A1

Demand for access from host computer to a logical disk made by user

A2

Return result in response to access demand

A3

Specify host computer demanding access, logical disk to be accessed, kind of access, write-data quantity, etc.

A4

Send information on host computer demanding access, logical disk to be accessed, time, kind of access, and write-data quantity to computer where access-information history database exists

A5

Store received history information in access-information history database

FIG. 5

B1

Detect logical disk containing data to which access was made within a certain time period

B2

Detect combinations of logical disks using same physical disks by referring to physical disks which constitute detected logical disks

B3

Create prospective logical disks to minimize the number of combinations detected

B4

Extract access information of each logical disk

B5

Calculate increase rate of storage capacity of each logical disk

B6

Calculate required storage capacity and priority from remaining storage capacity and increase rate of each logical disk

B7

Create prospective logical disks from calculated result

FIG. 6

C1

Calculate rate of efficiency according to efficiency factor and overhead factor when adopting each prospective logical disk

C2

Delete prospective logical disks whose rate of efficiency is equal to or less than prescribed threshold value

C3

Form them as new logical disks in the order of the rate of efficiency and include in system

FIG. 7

ネットワーク　Network

7

Storage unit

63

Storage management unit

64

Storage-unit information storing database

71

Physical disk

72

Logical disk

96

Host computer

631

Logical disk formation management unit

634

Logical disk formation database

FIG. 8

8

Storage unit

81

Physical disk

82

Logical disk